U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-252 047

# LAKE WACCAMAW, COLUMBUS COUNTY, NORTH CAROLINA

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

PREPARED FOR
NATIONAL ENVIRONMENTAL RESEARCH CENTER

JUNE 1975

## TECHNICAL REPORT DATA
*(Please read Instructions on the reverse before completing)*

| | | |
|---|---|---|
| 1. REPORT NO. | 2. | 3. RECIPIENT'S ACCESSION NO. PB-252 047 |
| 4. TITLE AND SUBTITLE Report on Lake Waccamaw, Columbus County, North Carolina | | 5. REPORT DATE Prepared June 1975 |
| | | 6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff) | | 8. PERFORMING ORGANIZATION REPORT NO. Working Paper #391 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330 | | 10. PROGRAM ELEMENT NO. |
| | | 11. CONTRACT/GRANT NO. |
| 12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460 | | 13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 |
| | | 14. SPONSORING AGENCY CODE |

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| eutrophication<br>lakes<br>nutrients<br>phosphorus<br>nitrogen<br>loading | | 05B<br>05C |

PRICES SUBJECT TO CHANGE

| | | |
|---|---|---|
| 18. DISTRIBUTION STATEMENT Release unlimited | 19. SECURITY CLASS (This Report) | 21. NO. OF PAGES 34 pp. |
| | 20. SECURITY CLASS (This page) | 22. PRICE $4.00 |

EPA Form 2220-1 (9-73)

34

PB 252 047

# U.S. ENVIRONMENTAL PROTECTION AGENCY
# NATIONAL EUTROPHICATION SURVEY

## WORKING PAPER SERIES

REPORT

ON

LAKE WACCAMAW

COLUMBUS COUNTY

NORTH CAROLINA

EPA REGION IV

WORKING PAPER No. 391

**PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY**

**An Associate Laboratory of the**

**NATIONAL ENVIRONMENTAL RESEARCH CENTER - CORVALLIS, OREGON**

**and**

**NATIONAL ENVIRONMENTAL RESEARCH CENTER - LAS VEGAS, NEVADA**

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

GPO—897-032

124129

# REPORT
# ON
# LAKE WACCAMAW
# COLUMBUS COUNTY
# NORTH CAROLINA
# EPA REGION IV
# WORKING PAPER No. 391

WITH THE COOPERATION OF THE

NORTH CAROLINA DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

AND THE

NORTH CAROLINA NATIONAL GUARD

JUNE, 1975

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# FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

## OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

## ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

## LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Carolina Department of Natural and Economic Resources for professional involvement and to the North Carolina National Guard for conducting the tributary sampling phase of the Survey.

Lewis R. Martin, Director of the Division of Environmental Management; Darwin L. Coburn, Chief of the Water Quality Section; and Julian R. Taylor, Supervisor of the Monitoring Program Unit; provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

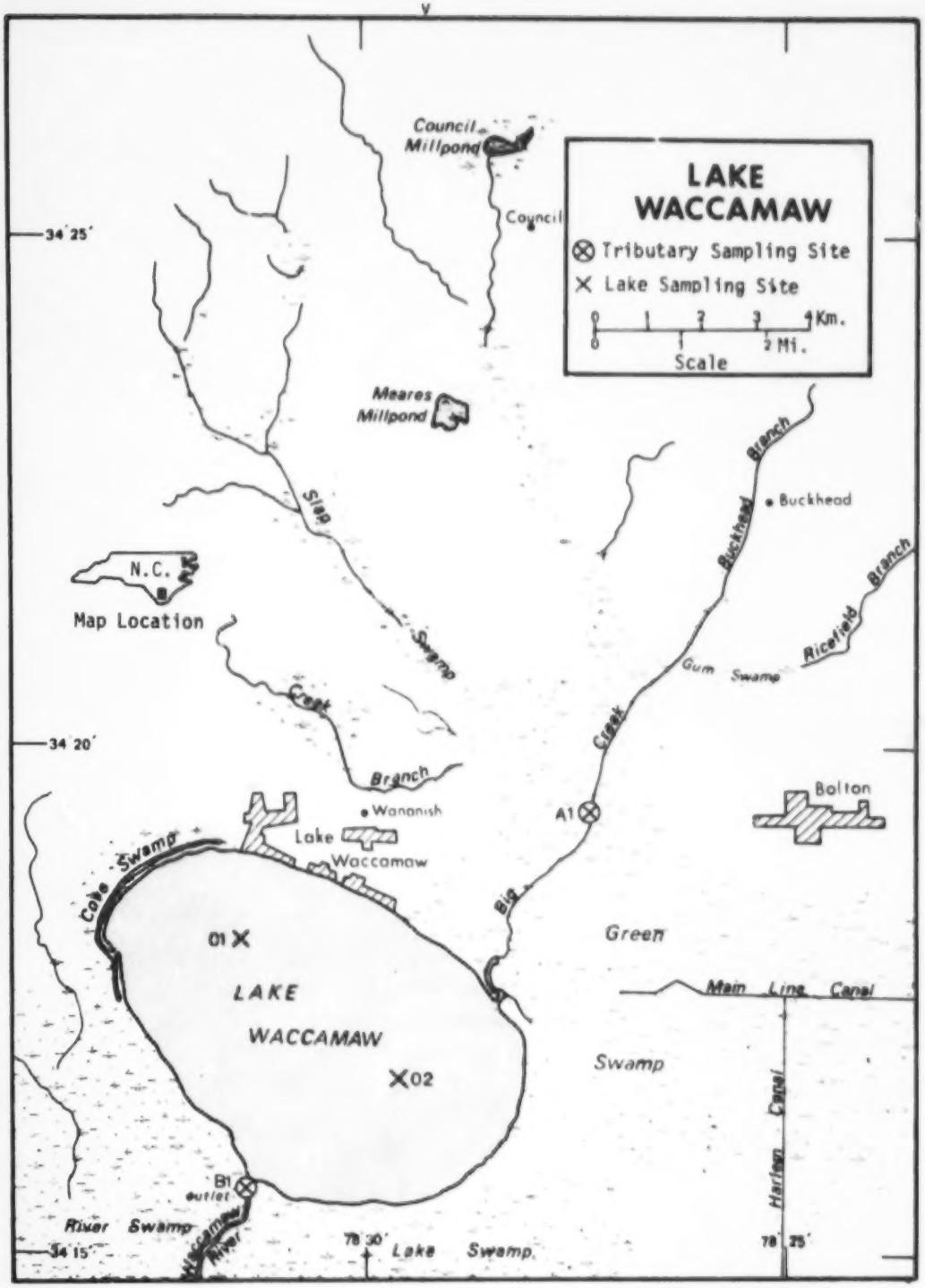
Major General William M. Buck, formerly Adjutant General of North Carolina, and Project Officer Colonel Arthur J. Bouchard, who directed the volunteer efforts of the North Carolina National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

# NATIONAL EUTROPHICATION SURVEY

## STUDY LAKES

## STATE OF NORTH CAROLINA

| LAKE NAME | COUNTY |
|---|---|
| Badin | Montgomery, Stanly |
| Blewett Falls | Anson, Richmond |
| Chatuge | Clay, NC; Towns, GA |
| Fontana | Graham, Swain |
| Hickory | Alexander, Caldwell, Catawba |
| High Rock | Davidson, Rowan |
| Hiwassee | Cherokee |
| James | Burke, McDowell |
| John H. Kerr (Nut Bush Creek) | Granville, Vance, Warren, NC; Halifax, Mecklenburg, VA |
| Junaluska | Haywood |
| Lookout Shoals | Alexander, Catawba, Iredell |
| Mountain Island | Gaston, Mecklenburg |
| Norman | Catawba, Iredell, Lincoln, Mecklenburg |
| Rhodhiss | Burke, Caldwell |
| Santeetlah | Graham |
| Tillery | Montgomery, Stanly |
| Waccamaw | Columbus |
| Waterville | Haywood |
| Wylie | Gaston, Mecklenburg, NC; York, SC |


LAKE WACCAMAW
Tributary Sampling Site
Lake Sampling Site
0 1 2 3 4 Km.
0 1 2 Mi.
Scale
Council Millpond
Council
Meares Millpond
Slap Swamp
Creek Branch
Buckhead Branch
Buckhead
Ricefield Branch
Gum Swamp
Big Creek
N.C.
Map Location
Wananish
Lake Waccamaw
Cove Swamp
Bolton
A1
01
LAKE WACCAMAW
02
Green Swamp
Main Line Canal
Harlem Canal
B1
outlet
River Swamp
Waccamaw River
Lake Swamp
34°25'
34°20'
34°15'
78°30'
78°25'

LAKE WACCAMAW

STORET NO. 3719

# I. CONCLUSIONS

## A. Trophic Condition:

Survey data indicate that Lake Waccamaw is mesotrophic, although the lake is quite shallow (max. depth of 3.3 meters), and total phosphorus concentrations were relatively high during the March sampling (0.020-0.063 mg/l). Using a relative trophic index combining six parameters, Lake Waccamaw ranked first in overall trophic quality among the 16 North Carolina lakes sampled in 1973*; however, that may not necessarily be true. Lake Waccamaw is surrounded by a swampy area and may simply be a dystrophic lake in which primary production is suppressed by lack of light penetration due to humic and tannic acids in the water.

Survey limnologists did not observe any surface algal scums; however, higher aquatic vegetation was noted along the shoreline.

## B. Rate-Limiting Nutrient:

The algal assay results and inorganic nitrogen to dissolved orthophosphorus ratios indicate Lake Waccamaw was phosphorus limited in March and July. However, the lake data indicate nitrogen limitation in September.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--During the sampling year, the phosphorus contribution of point sources amounted to 5.7% of the total phosphorus load reaching Lake Waccamaw and consisted entirely of estimated loads from septic tanks serving dwellings close to the lake. The present loading rate of 0.06 $g/m^2/yr$ is well below the rate proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 11).

2. Non-point sources--The phosphorus load from non-point sources accounted for 94.3% of the total reaching Lake Waccamaw. Big Creek contributed 58.4%, and the ungaged tributaries were estimated to have contributed 6.7% of the total. Due to the large surface area of this lake, direct precipitation is estimated to have accounted for 29.2% of the total phosphorus load.

## II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

### A. Lake Morphometry††:

1. Surface area: 36.17 kilometers$^2$.
2. Mean depth: 1.5 meters (estimated).
3. Maximum depth: 3.3 meters.
4. Volume: $54.3 \times 10^6$ m$^3$ (estimated).
5. Mean hydraulic retention time: 242 days (estimated).

### B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

| Name | Drainage area (km$^2$)* | Mean flow (m$^3$/sec)* |
|---|---|---|
| Big Creek | 194.2 | 2.0 |
| Minor tributaries & immediate drainage - | 20.8 | 0.6 |
| Totals | 215.0 | 2.6 |

2. Outlet -

| | | |
|---|---|---|
| Waccamaw River | 251.2** | 2.6 |

### C. Precipitation***:

1. Year of sampling: 123.0 centimeters.
2. Mean annual: 117.9 centimeters.

---

† Table of metric conversions--Appendix B.
†† Park, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

## III. LAKE WATER QUALITY SUMMARY

Lake Waccamaw was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the two stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1 and 1.5 meters at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE WACCAMAW
STORET CODE 3719

| PARAMETER | 1ST SAMPLING ( 3/22/73) 2 SITES RANGE | MEAN | MEDIAN | 2ND SAMPLING ( 7/ 5/73) 2 SITES RANGE | MEAN | MEDIAN | 3RD SAMPLING ( 9/20/73) 2 SITES RANGE | MEAN | MEDIAN |
|---|---|---|---|---|---|---|---|---|---|
| TEMP (C) | 13.6 - 14.5 | 14.0 | 14.0 | 29.4 - 30.2 | 29.8 | 29.8 | 25.8 - 26.2 | 26.0 | 26.0 |
| DISS OXY (MG/L) | 8.4 - 9.6 | 9.0 | 9.0 | 6.6 - 6.8 | 6.7 | 6.7 | 5.2 - 7.8 | 6.5 | 6.6 |
| CNDCTVY (MCROMO) | 55. - 55. | 55. | 55. | 60. - 65. | 63. | 63. | 63. - 66. | 65. | 65. |
| PH (STAND UNITS) | 6.7 - 7.4 | 7.0 | 6.9 | 7.1 - 7.2 | 7.2 | 7.2 | 6.7 - 7.2 | 6.9 | 6.9 |
| TOT ALK (MG/L) | 10. - 10. | 10. | 10. | 10. - 12. | 11. | 12. | 10. - 13. | 12. | 12. |
| TOT P (MG/L) | 0.020 - 0.063 | 0.041 | 0.041 | 0.014 - 0.019 | 0.016 | 0.016 | 0.014 - 0.019 | 0.016 | 0.015 |
| ORTHO P (MG/L) | 0.003 - 0.004 | 0.004 | 0.004 | 0.003 - 0.005 | 0.004 | 0.004 | 0.010 - 0.013 | 0.011 | 0.010 |
| NO2+NO3 (MG/L) | 0.050 - 0.060 | 0.055 | 0.055 | 0.040 - 0.060 | 0.052 | 0.055 | 0.020 - 0.040 | 0.027 | 0.025 |
| AMMONIA (MG/L) | 0.060 - 0.070 | 0.067 | 0.070 | 0.070 - 0.080 | 0.077 | 0.080 | 0.040 - 0.070 | 0.052 | 0.050 |
| KJEL N (MG/L) | 0.300 - 0.500 | 0.450 | 0.500 | 0.600 - 0.700 | 0.625 | 0.600 | 0.600 - 1.200 | 0.875 | 0.850 |
| INORG N (MG/L) | 0.120 - 0.130 | 0.122 | 0.120 | 0.120 - 0.140 | 0.130 | 0.130 | 0.060 - 0.110 | 0.080 | 0.075 |
| TOTAL N (MG/L) | 0.350 - 0.560 | 0.505 | 0.555 | 0.640 - 0.750 | 0.677 | 0.660 | 0.620 - 1.240 | 0.902 | 0.875 |
| CHLRPYL A (UG/L) | 4.3 - 6.2 | 5.2 | 5.2 | 2.0 - 2.9 | 2.4 | 2.4 | 3.0 - 3.1 | 3.0 | 3.0 |
| SECCHI (METERS) | 1.0 - 1.0 | 1.0 | 1.0 | 0.3 - 1.8 | 1.1 | 1.1 | 1.2 - 1.4 | 1.3 | 1.3 |

B. Biological characteristics:

1. Phytoplankton -

| Sampling Date | Dominant Genera | Algal units per ml |
|---|---|---|
| 03/22/73 | 1. Melosira | 1,653 |
| | 2. Synedra | 73 |
| | 3. Dinobryon | 44 |
| | 4. Cryptomonas | 44 |
| | 5. Lyngbya | 29 |
| | Other genera | 89 |
| | Total | 1,932 |
| 07/05/73 | 1. Aphanocapsa | 927 |
| | 2. Microcystis | 524 |
| | 3. Chlorella | 302 |
| | 4. Lyngbya | 262 |
| | 5. Flagellates | 101 |
| | Other genera | 502 |
| | Total | 2,618 |
| 09/20/73 | 1. Gomphosphaeria | 233 |
| | 2. Flagellates | 198 |
| | 3. Dinoflagellates | 90 |
| | 4. Cosmarium | 72 |
| | 5. Melosira | 54 |
| | Other genera | 161 |
| | Total | 801 |

2. Chlorophyll a -

| Sampling Date | Station Number | Chlorophyll a (µg/l) |
|---|---|---|
| 03/22/73 | 01 | 4.3 |
| | 02 | 6.2 |
| 07/05/73 | 01 | 2.9 |
| | 02 | 2.0 |
| 09/20/73 | 01 | 3.1 |
| | 02 | 3.0 |

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

| Spike (mg/l) | Ortho P Conc. (mg/l) | Inorganic N Conc. (mg/l) | Maximum yield (mg/l-dry wt.) |
|---|---|---|---|
| Control | 0.008 | 0.064 | 0.1 |
| 0.050 P | 0.058 | 0.064 | 1.0 |
| 0.050 P + 1.0 N | 0.058 | 1.064 | 17.4 |
| 1.0 N | 0.008 | 1.064 | 0.1 |

2. Discussion -

The algal assay results should be considered with some qualifications because the inorganic nitrogen concentration in the assay sample was approximately 50% of the concentration observed in the lake. Nevertheless, the assay results indicate that the lake was phosphorus limited, and this was substantiated by the 30 to 1 inorganic nitrogen to orthophosphorus ratio as determined by lake sampling. The July N/P ratio was 32/1, also indicating phosphorus limitation. However, in September, the N/P ratio was 7/1 indicating nitrogen limitation at that time.

## IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Carolina National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of January and February when two samples were collected. Sampling was begun in March, 1973, and was completed in February, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Carolina District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station A-1 and multiplying by the ZZ area in $km^2$.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

| Source | kg P/ yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Big Creek | 1,270 | 58.4 |
| b. Minor tributaries & immediate drainage (non-point load) - | 145 | 6.7 |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks* - | 125 | 5.7 |
| e. Known industrial - None | - | - |
| f. Direct precipitation** - | 635 | 29.2 |
| Total | 2,175 | 100.0 |

2. Outputs -

Lake outlet - Waccamaw River 1,270

3. Net annual P accumulation - 905 kg.

* Estimate based on 69 lakeshore residences and the town of Lake Waccamaw (pop. 924); see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

| Source | kg N/ yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Big Creek | 53,500 | 52.0 |
| b. Minor tributaries & immediate drainage (non-point load) - | 5,720 | 5.6 |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks* - | 4,675 | 4.5 |
| e. Known industrial - None | - | - |
| f. Direct precipitation** - | 39,050 | 37.9 |
| Total | 102,945 | 100.0 |

2. Outputs -

Lake outlet - Waccamaw River 60,215

3. Net annual N accumulation - 42,730 kg.

* Estimate based on 69 lakeshore residences and the town of Lake Waccamaw (pop. 924); see Working Paper No. 175.
** See Working Paper No. 175.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

| Tributary | kg P/km²/yr | kg N/km²/yr |
|---|---|---|
| Big Creek | 7 | 275 |

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

| | Total Phosphorus | | Total Nitrogen | |
|---|---|---|---|---|
| | Total | Accumulated | Total | Accumulated |
| grams/m²/yr | 0.06 | 0.03 | 2.8 | 1.2 |

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Waccamaw:

| | |
|---|---|
| "Dangerous" (eutrophic rate) | 0.30 |
| "Permissible" (oligotrophic rate) | 0.15 |

## V. LITERATURE REVIEWED

Park, David, 1974. Personal communication (lake morphometry). NC Dept. of Nat. & Econ. Resources, Raleigh.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Weiss, Charles M., 1972. A proposal to the Water Resources Research Institute of the University of North Carolina. The trophic state of North Carolina lakes, covering the period from July 1, 1972, to June 30, 1973. U. of North Carolina, Chapel Hill.

# VI. APPENDICES

## APPENDIX A

## LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | LAKE NAME | INDEX NO |
|---|---|---|---|
| 1 | 3719 | LAKE WACCAMAW | 534 |
| 2 | 3716 | SANTEELAH LAKE | 446 |
| 3 | 3711 | MOUNTAIN ISLAND LAKE | 419 |
| 4 | 3707 | HIWASSEE LAKE | 414 |
| 5 | 3704 | FONTANA LAKE | 392 |
| 6 | 3713 | LAKE NORMAN | 346 |
| 7 | 3708 | LAKE JAMES | 334 |
| 8 | 3710 | LOOKOUT SHOALS | 327 |
| 9 | 3715 | RHODHISS LAKE | 296 |
| 10 | 3705 | LAKE HICKORY | 283 |
| 11 | 3717 | LAKE TILLERY | 246 |
| 12 | 3709 | LAKE JUNALUSKA | 220 |
| 13 | 3702 | BLEWETT FALLS LAKE | 200 |
| 14 | 3718 | WATERVILLE RESERVOIR | 140 |
| 15 | 3701 | BADIN LAKE | 124 |
| 16 | 3706 | HIGH ROCK LAKE | 76 |

LAKE DATA TO BE USED IN RANKINGS

| LAKE CODE | LAKE NAME | MEDIAN TOTAL P | MEDIAN INORG N | 500-MEAN SEC | MEAN CHLORA | 15-MIN DO | MEDIAN DISS ORTHO P |
|---|---|---|---|---|---|---|---|
| 3701 | BADIN LAKE | 0.042 | 0.680 | 466.750 | 7.190 | 14.900 | 0.012 |
| 3702 | BLEWETT FALLS LAKE | 0.090 | 0.655 | 476.889 | 4.167 | 10.800 | 0.034 |
| 3704 | FONTANA LAKE | 0.011 | 0.550 | 392.650 | 3.438 | 14.900 | 0.007 |
| 3705 | LAKE HICKORY | 0.047 | 0.320 | 461.000 | 7.275 | 13.400 | 0.008 |
| 3706 | HIGH ROCK LAKE | 0.090 | 0.580 | 477.454 | 14.283 | 14.800 | 0.017 |
| 3707 | HIWASSEE LAKE | 0.015 | 0.240 | 420.555 | 5.678 | 14.200 | 0.007 |
| 3708 | LAKE JAMES | 0.020 | 0.160 | 428.866 | 7.660 | 14.800 | 0.006 |
| 3709 | LAKE JUNALUSKA | 0.031 | 0.560 | 462.000 | 7.233 | 14.200 | 0.009 |
| 3710 | LOOKOUT SHOALS | 0.026 | 0.370 | 459.167 | 4.200 | 13.800 | 0.008 |
| 3711 | MOUNTAIN ISLAND LAKE | 0.018 | 0.270 | 462.000 | 5.580 | 12.800 | 0.005 |
| 3713 | LAKE NORMAN | 0.019 | 0.330 | 446.667 | 5.807 | 14.800 | 0.005 |
| 3715 | RHODHISS LAKE | 0.061 | 0.305 | 462.111 | 3.578 | 13.600 | 0.019 |
| 3716 | SANTEELAH LAKE | 0.011 | 0.160 | 366.400 | 5.360 | 14.800 | 0.006 |
| 3717 | LAKE TILLERY | 0.040 | 0.470 | 468.600 | 6.827 | 13.600 | 0.008 |
| 3718 | WATERVILLE RESERVOIR | 0.103 | 0.860 | 468.333 | 3.817 | 14.400 | 0.041 |
| 3719 | LAKE WACCAMAW | 0.018 | 0.120 | 455.667 | 3.583 | 9.800 | 0.004 |

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

| LAKE CODE | LAKE NAME | MEDIAN TOTAL P | MEDIAN INORG N | 500-MEAN SEC | MEAN CHLORA | 15-MIN DO | MEDIAN DISS ORTHO P | INDEX NO |
|---|---|---|---|---|---|---|---|---|
| 3701 | BADIN LAKE | 33 ( 5) | 7 ( 1) | 27 ( 4) | 27 ( 4) | 3 ( 0) | 27 ( 4) | 124 |
| 3702 | BLEWETT FALLS LAKE | 7 ( 1) | 13 ( 2) | 7 ( 1) | 73 ( 11) | 93 ( 14) | 7 ( 1) | 200 |
| 3704 | FONTANA LAKE | 100 ( 15) | 33 ( 5) | 93 ( 14) | 100 ( 15) | 3 ( 0) | 63 ( 9) | 392 |
| 3705 | LAKE HICKORY | 27 ( 4) | 60 ( 9) | 53 ( 8) | 13 ( 2) | 80 ( 12) | 50 ( 7) | 283 |
| 3706 | HIGH ROCK LAKE | 13 ( 2) | 20 ( 3) | 0 ( 0) | 0 ( 0) | 23 ( 2) | 20 ( 3) | 76 |
| 3707 | HIWASSEE LAKE | 87 ( 13) | 80 ( 12) | 87 ( 13) | 47 ( 7) | 50 ( 7) | 63 ( 9) | 414 |
| 3708 | LAKE JAMES | 60 ( 9) | 87 ( 13) | 80 ( 12) | 7 ( 1) | 23 ( 2) | 77 ( 11) | 334 |
| 3709 | LAKE JUNALUSKA | 47 ( 7) | 27 ( 4) | 43 ( 6) | 20 ( 3) | 50 ( 7) | 33 ( 5) | 220 |
| 3710 | LOOKOUT SHOALS | 53 ( 8) | 47 ( 7) | 60 ( 9) | 67 ( 10) | 60 ( 9) | 40 ( 6) | 327 |
| 3711 | MOUNTAIN ISLAND LAKE | 73 ( 11) | 73 ( 11) | 43 ( 6) | 53 ( 8) | 87 ( 13) | 90 ( 13) | 419 |
| 3713 | LAKE NORMAN | 67 ( 10) | 53 ( 8) | 73 ( 11) | 40 ( 6) | 23 ( 2) | 90 ( 13) | 346 |
| 3715 | RHODHISS LAKE | 20 ( 3) | 67 ( 10) | 33 ( 5) | 93 ( 14) | 70 ( 10) | 13 ( 2) | 296 |
| 3716 | SANTEELAH LAKE | 93 ( 14) | 93 ( 14) | 100 ( 15) | 60 ( 9) | 23 ( 2) | 77 ( 11) | 446 |
| 3717 | LAKE TILLERY | 40 ( 6) | 40 ( 6) | 13 ( 2) | 33 ( 5) | 70 ( 10) | 50 ( 7) | 246 |
| 3718 | WATERVILLE RESERVOIR | 0 ( 0) | 0 ( 0) | 20 ( 3) | 80 ( 12) | 40 ( 6) | 0 ( 0) | 140 |
| 3719 | LAKE WACCAMAW | 80 ( 12) | 100 ( 15) | 67 ( 10) | 87 ( 13) | 100 ( 15) | 100 ( 15) | 534 |

APPENDIX B

CONVERSIONS FACTORS

## CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x $10^{-4}$ = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 10/21/75

LAKE CODE 3719 LAKE WACCAMAW

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 97.00

NORMALIZED FLOWS(CFS)

| TRIBUTARY | SUB-DRAINAGE AREA(SQ MI) | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3719A1 | 75.00 | 85.00 | 120.00 | 145.00 | 100.00 | 33.00 | 32.00 | 76.00 | 69.00 | 73.00 | 46.00 | 32.00 | 46.00 | 71.15 |
| 3719B1 | 97.00 | 110.00 | 155.00 | 188.00 | 130.00 | 43.00 | 40.00 | 98.00 | 89.00 | 94.00 | 59.00 | 41.00 | 60.00 | 91.91 |
| 3719ZZ | 22.00 | 25.00 | 35.00 | 43.00 | 30.00 | 10.00 | 8.00 | 22.00 | 20.00 | 21.00 | 13.00 | 9.00 | 14.00 | 20.76 |

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 97.00
SUM OF SUB-DRAINAGE AREAS = 97.00

TOTAL FLOW IN = 1107.00
TOTAL FLOW OUT = 1107.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

| TRIBUTARY | MONTH | YEAR | MEAN FLOW | DAY | FLOW | DAY | FLOW | DAY | FLOW |
|---|---|---|---|---|---|---|---|---|---|
| 3719A1 | 3 | 73 | 175.00 | 24 | 140.00 | | | | |
| | 4 | 73 | 300.00 | 24 | 105.00 | | | | |
| | 5 | 73 | 26.00 | 23 | 14.00 | | | | |
| | 6 | 73 | 14.00 | 27 | 34.00 | | | | |
| | 7 | 73 | 27.00 | 19 | 19.00 | | | | |
| | 8 | 73 | 26.00 | 24 | 36.00 | | | | |
| | 9 | 73 | 22.00 | 26 | 11.00 | | | | |
| | 10 | 73 | 12.00 | 29 | 5.00 | | | | |
| | 11 | 73 | 4.00 | 29 | 3.50 | | | | |
| | 12 | 73 | 28.00 | 19 | 23.00 | | | | |
| | 1 | 74 | 50.00 | 7 | 55.00 | 21 | 48.00 | | |
| | 2 | 74 | 180.00 | 4 | 90.00 | 18 | 215.00 | | |
| 3719B1 | 3 | 73 | 230.00 | 24 | 178.00 | | | | |
| | 4 | 73 | 400.00 | 24 | 136.00 | | | | |
| | 5 | 73 | 35.00 | 23 | 17.00 | | | | |
| | 6 | 73 | 18.00 | 27 | 44.00 | | | | |
| | 7 | 73 | 35.00 | 19 | 24.00 | | | | |
| | 8 | 73 | 34.00 | 24 | 46.00 | | | | |
| | 9 | 73 | 28.00 | 26 | 15.00 | | | | |
| | 10 | 73 | 16.00 | 29 | 6.50 | | | | |
| | 11 | 73 | 5.00 | 29 | 5.50 | | | | |
| | 12 | 73 | 35.00 | 19 | 29.00 | | | | |
| | 1 | 74 | 65.00 | 7 | 70.00 | 21 | 63.00 | | |
| | 2 | 74 | 230.00 | 4 | 120.00 | 18 | 280.00 | | |
| 3719ZZ | 3 | 73 | 52.00 | | | | | | |
| | 4 | 73 | 90.00 | | | | | | |
| | 5 | 73 | 7.70 | | | | | | |
| | 6 | 73 | 4.20 | | | | | | |
| | 7 | 73 | 7.90 | | | | | | |
| | 8 | 73 | 7.70 | | | | | | |
| | 9 | 73 | 6.40 | | | | | | |
| | 10 | 73 | 3.00 | | | | | | |
| | 11 | 73 | 1.00 | | | | | | |
| | 12 | 73 | 6.00 | | | | | | |
| | 1 | 74 | 15.00 | | | | | | |
| | 2 | 74 | 50.00 | | | | | | |

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/10/20

371901
34 18 11.0 078 31 28.0
LAKE WACCAMAW
37047 NORTH CAROLINA

11EPALES 2111202
3 0008 FEET DEPTH

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00010 WATER TEMP CENT | 00300 DO MG/L | 00077 TRANSP SECCHI INCHES | 00094 CNDUCTVY FIELD MICROMHO | 00400 PH SU | 00410 T ALK CACO3 MG/L | 00610 NH3-N TOTAL MG/L | 00625 TOT KJEL N MG/L | 00630 NO2&NO3 N-TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73/03/22 | 15 | 25 0000 | 14.5 | | 40 | 55 | 6.70 | 10K | 0.070 | 0.500 | 0.060 | 0.004 |
| | 15 | 25 0004 | 14.5 | 8.4 | | 55 | 6.80 | 10K | 0.070 | 0.300 | 0.050 | 0.003 |
| 73/07/05 | 11 | 15 0000 | 30.2 | | 72 | 65 | 7.10 | 12 | 0.080 | 0.600 | 0.040 | 0.004 |
| | 11 | 15 0005 | 29.9 | 6.8 | | 63 | 7.20 | 11 | 0.070 | 0.600 | 0.060 | 0.005 |
| 73/09/20 | 11 | 05 0000 | 26.2 | 5.2 | 54 | 65 | 7.20 | 13 | 0.070 | 1.200 | 0.040 | 0.013 |
| | 11 | 05 0005 | 26.2 | 5.6 | | 65 | 6.90 | 10 | 0.040 | 0.600 | 0.020 | 0.010 |

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00665 PHOS-TOT MG/L P | 32217 CHLRPHYL A UG/L |
|---|---|---|---|---|
| 73/03/22 | 15 | 25 0000 | 0.024 | 4.3 |
| | 15 | 25 0004 | 0.020 | |
| 73/07/05 | 11 | 15 0000 | 0.014 | 2.9 |
| | 11 | 15 0005 | 0.019 | |
| 73/09/20 | 11 | 05 0000 | 0.019 | 3.1 |
| | 11 | 05 0005 | 0.017 | |

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

371902
34 16 42.0 078 29 35.0
LAKE WACCAMAW
37047 NORTH CAROLINA

11EPALES
3

2111202
0008 FEET DEPTH

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00010 WATER TEMP CENT | 00300 DO MG/L | 00077 TRANSP SECCHI INCHES | 00094 CNDUCTVY FIELD MICROMHO | 00400 PH SU | 00410 T ALK CACO3 MG/L | 00610 NH3-N TOTAL MG/L | 00625 TOT KJEL N MG/L | 00630 NO2&NO3 N-TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73/03/22 | 16 00 | 0000 | 13.6 | | 40 | 55 | 7.00 | 10K | 0.070 | 0.500 | 0.050 | 0.004 |
| | 16 00 | 0004 | 13.6 | 9.6 | | 55 | 7.40 | 10K | 0.060 | 0.500 | 0.060 | 0.004 |
| 73/07/05 | 11 45 | 0000 | 29.7 | | 12 | 63 | 7.20 | 10K | 0.080 | 0.700 | 0.050 | 0.003 |
| | 11 45 | 0004 | 29.4 | 6.6 | | 60 | 7.20 | 12 | 0.080 | 0.600 | 0.060 | 0.004 |
| 73/09/20 | 11 40 | 0000 | 25.8 | 7.8 | 48 | 63 | 6.90 | 11 | 0.060 | 1.100 | 0.030 | 0.010 |
| | 11 40 | 0005 | 25.8 | 7.6 | | 66 | 6.70 | 12 | 0.040 | 0.600 | 0.020 | 0.011 |

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00665 PHOS-TOT MG/L P | 32217 CHLRPHYL A UG/L |
|---|---|---|---|---|
| 73/03/22 | 16 00 | 0000 | 0.058 | 6.2 |
| | 16 00 | 0004 | 0.063 | |
| 73/07/05 | 11 45 | 0000 | 0.015 | 2.0 |
| | 11 45 | 0004 | 0.017 | |
| 73/09/20 | 11 40 | 0000 | 0.014 | 3.0 |
| | 11 40 | 0005 | 0.014 | |

K VALUE KNOWN TO BE
LESS THAN INDICATED

# APPENDIX E

# TRIBUTARY DATA

STORET RETRIEVAL DATE 75/10/20

3719A1 LS3719A1
34 19 30.0 078 27 30.0
BIG CREEK
37087 15 BOLTON
I/LAKE WACCAMAW
HWYS 74 AND 76 BRDG 2 MI E OF WACCAMAW
11EPALES 2111204
4 0000 FEET DEPTH

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 73/03/24 | 14 | 08 | 0.010K | 0.670 | 0.018 | 0.005K | 0.005K |
| 73/04/24 | 12 | 00 | 0.013 | 0.780 | 0.028 | 0.006 | 0.020 |
| 73/05/23 | 10 | 15 | 0.010K | 0.800 | 0.024 | 0.010 | 0.020 |
| 73/06/27 | 11 | 35 | 0.040 | 0.200 | 0.160 | 0.009 | 0.030 |
| 73/07/19 | 11 | 35 | 0.016 | 0.800 | 0.052 | 0.006 | 0.015 |
| 73/08/24 | | | 0.010K | 1.150 | 0.031 | 0.005K | 0.015 |
| 73/09/26 | 11 | 00 | 0.010K | | 0.088 | 0.017 | |
| 73/10/29 | 12 | 10 | 0.010K | 0.950 | 0.075 | 0.006 | |
| 73/11/29 | 11 | 25 | 0.020 | 1.350 | 0.048 | 0.040 | 0.097 |
| 73/12/19 | 11 | 20 | 0.048 | 0.400 | 0.036 | 0.005K | 0.005 |
| 74/01/07 | 11 | 23 | 0.008 | 0.400 | 0.040 | 0.005K | 0.005K |
| 74/01/21 | 11 | 35 | 0.016 | 1.200 | 0.060 | 0.008 | 0.008 |
| 74/02/04 | 11 | 40 | 0.036 | 1.100 | 0.070 | 0.005 | 0.015 |
| 74/02/18 | 11 | 20 | 0.036 | 0.300 | 0.025 | 0.005 | 0.005 |

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

371981 LS371981
34 55 00.0 078 31 30.0
WACCAMAW RIVER
37 15 WHITEVILLE
O/LAKE WACCAMAW
DISCH CANAL OF DAM 4.4 MI N OF LK WACCAM
11EPALES 2111204
4 0000 FEET DEPTH

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 73/03/24 | 12 | 34 | 0.010K | 0.710 | 0.046 | 0.005K | 0.015 |
| 73/04/24 | 11 | 15 | 0.010K | 0.500 | 0.020 | 0.005K | 0.020 |
| 73/05/23 | 10 | 45 | 0.010K | 0.500 | 0.007 | 0.005K | 0.015 |
| 73/06/27 | 12 | 05 | 0.016 | 0.690 | 0.050 | 0.005K | 0.020 |
| 73/07/19 | 12 | 05 | 0.010K | 2.100 | 0.029 | 0.005K | 0.015 |
| 73/08/24 | | | 0.010K | 0.710 | 0.012 | 0.005K | 0.015 |
| 73/09/26 | 11 | 40 | 0.010K | | 0.084 | 0.007 | |
| 73/10/29 | 12 | 39 | 0.010K | 0.650 | 0.067 | 0.005K | |
| 73/11/29 | 11 | 45 | 0.010K | 0.900 | 0.040 | 0.008 | |
| 73/12/19 | 11 | 55 | 0.024 | 0.300 | 0.012 | 0.005K | 0.025 |
| 74/01/07 | 11 | 00 | 0.010K | 0.400 | 0.020 | 0.005K | 0.010 |
| 74/01/21 | 12 | 00 | 0.010K | 0.200 | 0.012 | 0.005K | 0.005K |
| 74/02/04 | 12 | 10 | 0.020 | 1.300 | 0.050 | 0.005K | 0.020 |
| 74/02/14 | 11 | 45 | 0.020 | 0.400 | 0.020 | 0.005K | 0.010 |

K VALUE KNOWN TO BE
LESS THAN INDICATED